

NO 000 000

RECONSTRUCTED AIR FORCE POSITIONS: A  
REVIEW OF THEIR DEVELOPMENT (U) AIR FORCE INST OF TECH  
WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.

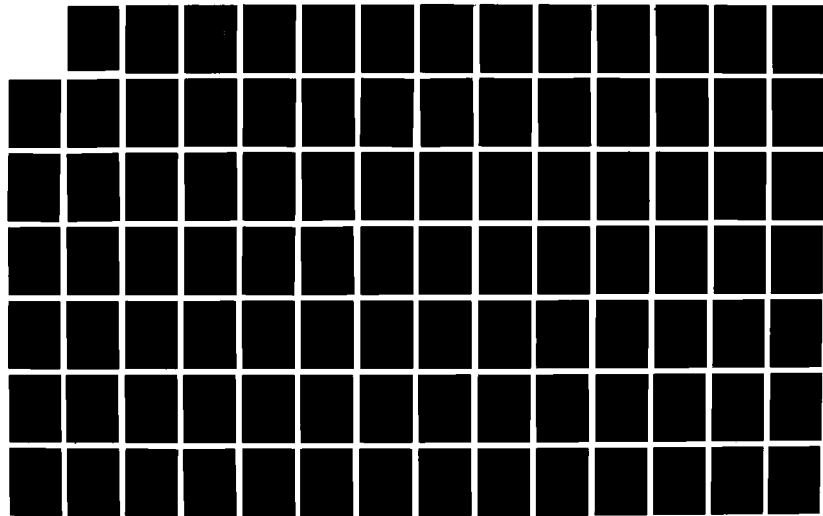
1/2

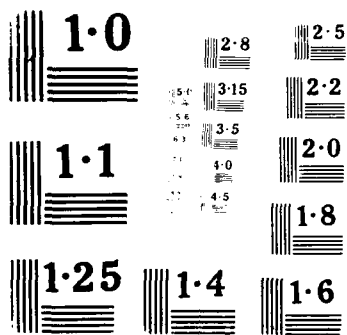
UNCLASSIFIED

T R FERKINHOFF SEP 89 AFIT/OLM/LSR/895-22

F/O 5/2

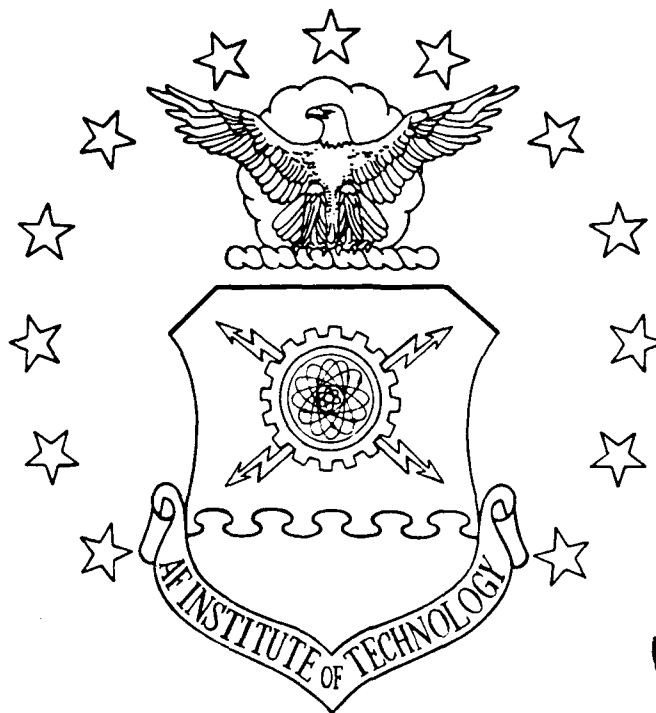
NL





AD-A215 555

2



DTIC FILE COPY

DTIC  
ELECTE  
DEC 20 1989  
S Dcy D

READABILITY FORMULAS  
AND AIR FORCE PUBLICATIONS:  
A REVIEW OF THEIR DEVELOPMENT  
AND AN EXAMINATION OF THEIR APPLICATION

THESIS

Thomas R. Ferkinhoff  
Captain, USAF  
AFIT/GLM/LSR/89S-22

**DISTRIBUTION STATEMENT A**  
Approved for public release  
Distribution Unlimited

DEPARTMENT OF THE AIR FORCE  
AIR UNIVERSITY  
**AIR FORCE INSTITUTE OF TECHNOLOGY**

Wright-Patterson Air Force Base, Ohio

89 12 19 029

2

AFIT/GLM/LSR/89S-22

DTIC  
ELECTE  
DEC 20 1989  
S D D

READABILITY FORMULAS  
AND AIR FORCE PUBLICATIONS:  
A REVIEW OF THEIR DEVELOPMENT  
AND AN EXAMINATION OF THEIR APPLICATION

THESIS

Thomas R. Ferkinhoff  
Captain, USAF  
AFIT/GLM/LSR/89S-22

Approved for public release; distribution unlimited

The contents of the document are technically accurate, and no sensitive items, detrimental ideas, or deleterious information is contained therein. Furthermore, the views expressed in the document are those of the author and do not necessarily reflect the views of the School of Systems and Logistics, the Air University, the United States Air Force, or the Department of Defense.

Accession For		1
NTIS	CRA&I	<input checked="" type="checkbox"/>
DTIC	TAB	<input type="checkbox"/>
Unannounced		<input type="checkbox"/>
Justification		
By		
Distribution /		
Availability Codes		
Dist	Avail and/or Special	
A-1		

READABILITY FORMULAS  
AND AIR FORCE PUBLICATIONS:  
A REVIEW OF THEIR DEVELOPMENT  
AND AN EXAMINATION OF THEIR APPLICATION

THESIS

Presented to the Faculty of the  
School of Systems and Logistics  
of the Air Force Institute of Technology  
Air University

In Partial Fulfillment of the  
Requirements for the Degree of  
Masters of Science in Logistics Management

Thomas R. Ferkinhoff, B.A., M.S.

Captain, USAF

September 1989

Approved for public release: distribution unlimited

### Acknowledgments

In the course of this research many have provided valuable assistance. I wish to thank the library staff at the Air Force Institute of Technology for their timely assistance in my search for obtaining the various articles used in this research. I am also deeply indebted to my advisor, Dr. David K. Vaughan, for his encouragement and direction. Finally, I am eternally grateful to my lovely wife Sandra for her understanding and her support during these last few months.

Thomas R. Ferkinhoff

## Table of Contents

	page
Acknowledgements.....	ii
Abstract.....	vi
1. Overview.....	1
General Issue.....	1
Problem Statement.....	4
Methodology.....	5
Limitations of Study.....	7
Presentation of the Material.....	7
2. The Early Development of Readability Formulas: 1923-1942.....	9
Historical Background.....	9
Lively and Pressly.....	11
Washburne and Vogel.....	13
Dolch.....	14
Lewerenz.....	15
Johnson.....	16
Thorndike.....	17
Ojemann.....	18
Dale and Tyler.....	19
McClusky.....	20
Gray and Leary.....	21
Washburne and Morphett.....	22
Lorge.....	23
Kessler.....	24

3. The Recent Development of Readability Formulas:	
1943-1989.....	25
Flesch.....	25
Dale and Chall.....	27
Farr, Jenkins, and Patterson.....	28
Gunning.....	29
Taylor.....	30
Smith and Senter.....	31
4. Readability Formulas and Their Applicability to The Military Publication.....	33
Caylor, Sticht, Fox, and Ford.....	33
Kincaid, Fishburne, Rogers, and Chissom.....	35
Hooke, DeLeo, and Slaughter.....	36
Smith and Kincaid,.....	37
Johnson, Relova, and Stafford.....	38
Mockovak.....	39
Kincaid, Aagard, O'Hara, and Cottrell.....	41
Kieras.....	41
Parallel Factors.....	42
Mockovak.....	43
Post and Price.....	44
Mathews, Valentine, and Sellman.....	45
Kern.....	46
Kniffin, Stevenson, Klare, Entin, Slaughter, and Hooke.....	47
Conclusions.....	49
5. A Synopsis and an Analysis of Current Readability Applications in the USAF.....	50

	page
Regulations.....	50
Procedural Manuals/Technical Orders.....	55
Conclusions.....	63
6. Conclusions and Recommendations.....	64
Conclusions.....	64
Recommendations.....	67
Appendix A: AFR 5-8 Listing of Simplifying Words and Phrases.....	68
Appendix B: AECMA Participants.....	74
Appendix C: Computational Methodology for Determining the RGL of Air Force TO's.....	76
Bibliography.....	81
Vita.....	86

Abstract

This thesis provides a foundation for future research on the subject of readability formulas and their use with Air Force publications. It examines readability's historical roots and studies pertaining to the topic of readability and its application to the United States Military in general, and the United States Air Force in particular.

This presentation also describes and analyzes Air Force policies relative to the readability of its publications. The results of this analysis indicate that the current procedures, employed by the Air Force, inadequately address the readability of publications. The specific problems that were identified fell under three areas.

The first area addresses the Air Force's decision to write Technical Orders to a ninth grade reading level. This decision is unsubstantiated on either economic or efficiency grounds.

The second problem concerns the questionable methodology used by the Air Force to verify that the desired reading grade level has indeed been achieved. The problem revolves around the use and misuse of the Kincaid readability formula.

The final area for concern is the Air Force's decision to recommend using Association Europeene Des Constructeurs De Materiel Aerospatial (AECMA Simplified English Guide for the Preparation of Aircraft Maintenance Documentation in the Aerospace Maintenance Language) as an aid for producing simplified technical writing. This is a problem because AECMA has never been empirically tested.

READABILITY FORMULAS  
AND AIR FORCE PUBLICATIONS:A  
REVIEW OF THEIR DEVELOPMENT AND  
AN EXAMINATION OF THEIR APPLICATION

1. Overview

General Issues

The United States Air Force generally recruits high school graduates to be members of its enlisted forces. These individuals quite naturally, possess varied aptitudes and abilities; however, upon entering the service, they are required to be able to read and understand the numerous regulations, technical orders, and other government documents which are pertinent to their duties. Therefore, these publications must be written to a level commensurate with the reading skills of the intended audience. If they are not written to such a level, there is the possibility of tremendous damage to equipment, injury to personnel, and possibly fatalities (Kincaid and others, 1967:1; Johnson, K. and others, 1972:7; Hooke and others, 1979:5).

Because vital information is presented in these publications it is critically important that they be readable; but are they? If they are, we can all breathe a

collective sigh of relief, knowing that the service men and women, who are working on our planes, missiles, radars, and other vital systems for the defense of our country, are being given readable and understandable Technical Orders and maintenance documents. If, on the other hand, the materials presented to the service member are not in a readable form, the potential for loss is high. But what exactly constitutes a readable publication?

Thomas Huckin defines writing as readable "to the extent that its meaning can be easily and quickly comprehended for an intended purpose by an intended reader operating under normal conditions of alertness, motivation, time-pressure" (Huckin, 1983:91). In general, readability is measured according to the grade level required for understanding. Thus material with a readability level of 9 should be able to be understood by a reader who possesses a reading ability at the 9th grade level. Normally the methodology employed to test this relationship is in the form of readability formulas.

Klare, in his 1963 book The Measurement of Readability, states that a readability formula should serve as a predictive device which would provide a quantitative, objective estimate as to the difficulty level of a piece of writing. He adds that these formulas should be broad enough in scope so that they could provide estimates over a range of applicability and difficulty (Klare, 1963:33-34).

To develop this estimate, readability formulas in general use quantifiable syllable, word, sentence, or paragraph factors as determinants of a text's reading level. These factors, although employed differently by different researchers, are used with the ultimate goal of developing a mathematical technique for determining a text's readability level. Specifically the United States Air Force uses the Kincaid readability formula to assess the readability of its Technical Orders (for additional information on this subject see Appendix C, and the research of Kincaid and others discussed in chapter 4).

In this paper the subject of readability and readability formulas and their relationship to Air Force publications will be explored from the following perspective: first, readability's historical roots will be examined. Included in this evaluation will be a description of significant readability formulas. Next, studies pertaining to the topic of readability and its application to the United States Military in general, and the United States Air Force in particular, will be reviewed. Finally, conclusions will be drawn concerning the applicability of using readability formulas when writing military publications.

### Problem Statement

The United States Air Force's military and civilian members are given the responsibility for writing regulations, training materials, and other Air Force publications with little guidance on how to complete their tasks. Fortunately most of the individuals assigned the responsibility for writing these publications have the technical skills required to know what information should be included in them. Unfortunately, however, these same people may not have the requisite writing ability necessary to effectively transfer their knowledge to their audience by producing a readable document.

One likely scenario has the author seeking assistance from coworkers on how to best accomplish the tasking. From these sources the author could be given such advice as: "write it just like the old one," or "go to the Air Force 0-2 (a document listing all Air Force Regulations); I am sure they must have information on the subject."

If, on the one hand, our author decides to write the new document in the same format as the old one, any readability errors associated with the old document are likely to be repeated. If, on the other hand, the author chooses to investigate the Air Force 0-2, all types of directions are available on how to produce readable publications. Unfortunately, readability guidance is not easily located, nor is there any evidence for the validity

of the recommendations given. Therefore, the principal focus of this paper is to examine the current Air Force procedure for incorporating the subject of readability into its documents and to provide a useful synthesis of research on the impact of readability and its relationship to Air Force publications.

### Methodology

The primary purpose of this research is to provide a useful tool for the military member who is concerned with the subject of readability and its relationship to military publications. To accomplish this task, this paper begins with an extensive review of the topic. This review focuses on two areas: (1) the significant readability formulas that have developed over the years, and (2) the articles which deal with the topic of readability of the military publication.

To acquire information on significant readability formulas, the resources at the Air Force Institute of Technology (AFIT), the University of Dayton, and Wright State University were used to provide the fundamental data base. However, to obtain relevant information on the relationship between the subject of readability and military publications it was necessary to go beyond the resources available to a normal college library. In fact, a computerized literature search using the Defense Technical

Information Center (DTIC) system proved to be the primary source of data in acquiring articles which dealt with this topic. The DTIC system consists of three separate data bases, each of which specializes in a particular type of information: (1) The Research and Technology Work Unit Information System (WUIS) is a database of on-going Department Of Defense research and technology efforts at the work unit level. (2) The Technical Report (TR) database is a repository of bibliographic records of technical reports submitted to DTIC. And (3) the Independent Research and Development (IR&P) database is a database of contractors independent research and development efforts shared with the Department of Defense.

Information on the subject of readability and on the current procedures, techniques, and rules pertaining to this topic and its relationship to United States Air Force writing were acquired by consulting the Air Force's 0-2. All regulations related to the subject of readability were explored. As a result of this initial investigation, the following list of regulations was chosen for more detailed analysis:

AFR 5-1, "Air Force Publication Management Program"

AFR 5-8, "Preparing Air Force Publications"

AFR 8-2, "Air Force Technical Order System"

AFR 10-1, "Preparing Written Communications"

AFR 35-8, "Air Force Personnel Testing System"

Additional official information on this subject was acquired by analyzing military specifications MIL-M-38734B (Military Specification Manuals, Technical: General Style and Format Requirements), DOD-STD 1685 (Comprehensibility Standards for Technical Manuals), and MIL-STD-1752 (Military Standard Reading Level Requirements for Preparation of Technical Orders) Notice 1.

The Air Force unofficial guide to effective communication, Air Force Pamphlet 13-2, Tongue and Quill, was also reviewed for its applicability to this topic.

#### Limitations of Study

This thesis is not intended to assess the current readability of regulations, technical orders, or other Air Force publications; nor is it intended to act as an advocate for any particular readability formula. Additionally, the only readability formulas discussed in detail in this paper are those that have advanced the scope of this field or those that directly affected the relationship of readability assessment methodologies and military publications.

#### Presentation of the Material

Chapter two of this thesis discusses early research in readability, including an analysis of significant readability formulas. This material is included to provide a fundamental understanding of this subject, and to

establish the necessary background for comprehending aspects of readability as they pertain to the military publications.

Chapter three also examines readability formulas. These formulas, however, are significantly different from those in chapter two. These formulas have been used to assess the readability of military documents, or they have been newly developed and thus address the topic of readability from a novel perspective.

Chapter four, which reviews the above mentioned relationship, is divided into three sub-sections: section one contains an exploration of readability formulas developed exclusively for military use; section two investigates articles dealing with the relationship between military publications and the topic of readability; and finally, section three analyzes articles which closely parallel the subject of readability.

Chapter five consists of an analysis of the Air Force's current procedure for ensuring the readability of its publications. This analysis includes: summaries of the techniques that the Air Force uses to obtain readable publications, a rationale (when available) for using the technique, and finally a critical assessment of that rationale.

Chapter six consists of conclusions based on the review of the literature and recommendations for future research.

## 2. The Early Development of Readability Formulas: 1923-1942

The principal focus of this chapter is to provide the novice with a brief background on the topic of readability and a description of significant, early readability formulas. This chapter describes the development of the readability formula from its birth in 1923 to its maturation in 1942.

### Historical Background

From the time when words were first invented and used for communication, it has been important for writers to consider their intended readers. For it is the author's choice of appropriate words and phrases which often make the difference between the reader experiencing effective communication or utter confusion. From biblical times the importance of readability has been repeatedly stressed in the literature. One of the favorite quotations of early advocates for clear expression comes from 1 Corinthians 14:9: "Except ye utter by the tongue words easily to be understood, how shall it be known what is spoken? For ye shall speak into the air."

The idea of trying to measure readability probably had its origins in an 1852 article written by Herbert Spencer, entitled "The Philosophy of Style." In this article Spencer showed how the judicious use of word choice by authors

allowed the reader to better comprehend a given subject. Spencer argued that humans have a limited capacity to comprehend information so that "time and effort devoted to the decipherment of meaning would be subtracted from the energy left to consider the meaning itself" (Hirsch, 1977:78). Spencer further stated that efficient writing is the key to making articles more readable, and that proper word choice was the key to that efficiency.

In 1989 and 1898 respectively, N. A. Ruberkin and F. W. Kaeding conducted separate studies which advanced Spencer's qualitative statements on readability. They attempted to provide a scientific basis for relating vocabulary choice to reading difficulties through word count procedures (Lorge, 1944:543-552).

The early works on word counts set the stage for what was easily the most important occurrence of the prereadability formula period, the publication in 1921 of The Teacher's Word Book, a text by E. L. Thorndike (Klare, 1963:30). In this book, and its subsequent revisions in 1932 and 1944, Thorndike examined samples of text and then listed words, based on the frequency with which they appeared in print. The idea was that the more often a word appeared in print, the more easily that word was thought to be understood.

According to Klare, Thorndike's research was important not only because it provided the impetus for the work of

Lively and Presser, who in 1923 developed the first readability formula, but also because it served as a basis for many future readability studies (Klare, 1963:30).

Word frequency, however, was not the only readability variable to be investigated during this time period (Lamoreaux, 1985:14). Other researchers looked at such diverse items as sentence length (Sherman, 1893:256-268) and the use of multisyllabic words (Bear, 1927) in their efforts to develop readability formulas, and in turn to assess an article's readability.

The specifics of how some of the early, significant readability formulas developed are listed below.

#### Lively and Pressly

The work of Lively and Pressly is important to the subject of readability not only because it represented the earliest acknowledged quantitative study using a readability formula, but also because it inspired future researchers to develop their own readability formulas (Chall, 1958).

The Lively and Pressly technique (1923) attempted to determine the vocabulary difficulty of a book. To accomplish this task, they systematically sampled 1000 words throughout a text and then applied the following procedure to those words: they calculated the "vocabulary range" or the number of distinct words appearing in the sample; they then assigned a difficulty index to each word based upon

Thorndike's Teacher's Word Book. A word found appearing in Thorndike's most frequent 1000 words was given a point value of ten, the other words in the book were assigned point values such that the less frequent they were, (based upon the Thorndike index) the lower point value they would receive. Words that did not appear at all in Thorndike's most common 10,000 words were assigned a point value of zero and were counted twice when calculating the "weighed median index number." The final step of the Lively and Pressly procedure consisted of simply calculating the median index for the sampled words. The lower the median index was scored, the more difficult the vocabulary was thought to be (Klare, 1963:37-38).

In an effort to confirm the reliability of this newly developed procedure, Lively and Pressly tested their readability formula against sixteen separate pieces of reading material which had been previously judged to be of different reading levels. The results of these tests indicated that their computed weighted median index agreed consistently with the previously judged materials' difficulty level. Continuing with their initial investigation, Lively and Pressly eventually established a weighted median index number for reading grade levels with a range of difficulty from second grade through college (Klare, 1963:37,38,75).

Lively and Pressly's work is regarded as important because it is given credit for creating an explosion of interest in developing readability formulas, an example of which is the work of Washburne and Vogel.

#### Washburne and Vogel

In 1928 Carleton Washburne and Mabel Vogel applied the Lively and Pressly formula to 700 children's books. They then determined the grade level of the children who liked the books by using the child's score on the Stanford Achievement Test. This grade level was then compared with the medium index score in the Lively and Pressly formula. From this comparison a correlation coefficient of .80 was obtained.

The Washburne and Vogel findings were significant, not only because they provided the first validation of a readability formula using an independent, outside criterion, but also because they provided a starting point from which these authors could develop their own readability formula (Klare, 1963:39).

The Vogel and Washburne procedure is of special interest to the student of readability because it is considered to be the precursor of the modern readability formula. Their innovative technique consisted of: choosing a sample passage of 1000 words from the book to be analyzed, counting the number of different words in that sample,

counting the total number of prepositions in the sample, determining the number of words not listed in Thorndike's list of 10,000 words, and then counting the number of simple sentences which appeared in a sample of 75 sentences. Once these steps were accomplished, the regression equation was used to determine the reading score (Klare, 1963:39). This score was computed by using the following formula:

$$A = .085 B + .101 C + .604 D - .411 E + 17.43$$

where A was equal to the reading score, B was equal to the number of different words in the sample, C was equal to the total number of prepositions, D was equal to the number of words not listed in Thorndike's 10,000 words, and E was equal to the number of simple sentences in a tested sample of 75 sentences.

### Dolch

Another author who explored the subject of readability during this time frame (1928) was Edward Dolch. Dolch examined textbooks written for grades one through four. In his analysis of articles' readability Dolch used the following five indices of difficulty: the percentage of difficult words (based on the Dolch's Combined Word Study List, the percentage of different words (again using the Dolch combined word study list), the degree of difficulty of words, the median frequency of difficult words, and finally the degree of difficulty for any supplementary reading

material (Dolch, 1928:170-183). Dolch found a wide degree of difference in the difficulty level of texts supposedly written for the same grade level.

### Lewerenz

A. S. Lewerenz explored the subject of readability from two entirely different perspectives. Because both approaches were unique they bear closer examination.

Lewerenz's first approach to the subject of readability (1929) was one of the oddest in the history of the subject. His four step technique consisted of: sampling a passage of 1000 words to determine the number of different words present; counting the number of words beginning with each letter of the alphabet and then calculating the percentage of words beginning with the letters W, H, and B (by his definition the easy words), as well as the percentage of words that started with an I or an E (again by his definition the hard words); consulting a table to obtain a normative score for each percentage; and finally computing an average score to provide a grade placement level score for the vocabulary (Klare, 1963:40-41).

Lewerenz's second attempt at measuring readability (1930) was different from his first effort, but equally bizarre. Rather than counting words which began with various letters of the alphabet, Lewerenz evaluated articles based on the ratio of Anglo-Saxon words to the ratio of

words with Greek or Roman (Latin) derivation. From the ratios obtained he assigned various grade levels to the articles (Klare, 1963:41). The more Anglo-Saxon words present in the article, the easier it was considered to read.

### Johnson

George R. Johnson (1930) sought to develop a readability formula that was simple to use and also reliable. His method of calculating the readability of a work simply consisted of: selecting thirty 100-word sections from the text to be analyzed, counting the number of polysyllabic words present in those sections, and determining what percentage of the total words examined were polysyllabic words. Johnson claimed that by using this method, a book's reading difficulty level could be determined in approximately 30 minutes.

Johnson's research cited specific evidence for the reliability of using the polysyllabic word count as a determinate of reading level. This information, which he claimed substantiated his conclusions, was obtained from four different sources: studies which show better understanding by students who read a story in mon-syllabic words than by those who read it in polysyllabic words, the inverse relation which exists between polysyllabic words and Thorndike's word frequency index, the increased use of

polysyllabic words in texts designed to be used by higher grade levels, and the close relationship between the number of polysyllabic words and the number of technical words used in the seven books he examined (Johnson, G., 1930:283-287).

A few years later Thorndike examined the subject of readability from a slightly different perspective.

#### Thorndike

In 1934 Thorndike developed a procedure for determining the readability of a book. His methodology consisted of the following two steps: sample at least 10,000 words from the text, and count the number of words included in each of the different categories of the Teacher's Word Book. Based on this count it was then possible to determine the grade level at which the book was written.

It is interesting to note that Thorndike's readability formula perhaps best characterized the early work in readability. This period was shaped by an emphasis on vocabulary as the primary determinate to predicting a subject's difficulty level, a dependence on the Teacher's Word Book as a method of determining a vocabulary's difficulty, and the use of relatively simple mathematical formulas for calculating a work's readability (Klare, 1963:44).

### Ojemann

In 1934 Ralph Ojemann approached the subject of readability from a novel perspective. He sought to empirically determine which factors were most closely related to reading difficulty. The factors Ojemann chose to investigate fell into three broad areas. The first area, sentence factors, was subdivided into: the number of simple sentences, the number of complex sentences, the number of compound sentences, the number of dependent clauses, the number of prepositions, the number of prepositions plus infinitives, the average length of the dependent clauses, and the ratio of total words in the independent clauses to the total words in a section.

The second area consisted of vocabulary factors. This section included six subsections: the percentage of words in Thorndike's first 1000 words, the percentage of words in Thorndike's first 2000 words, the percentage of words known by 70 percent of sixth grade pupils, the percentage of words known by 90 percent of sixth grade pupils, the mean difficulty of different words, and the mean difficulty for each word.

The final area Ojemann sought to investigate was qualitative factors. Included in this category were: the concreteness, as opposed to the abstraction, of a relation, the obscurity of expression, and the incoherence of expression (Klare, 1963:44-45).

As a result of his extensive investigation Ojemann found that there was a correlation at the .60 level or better between his vocabulary factors and an article's reading difficulty. For the sentence factors, only the number of simple sentences, the number of propositions, and the number of prepositions plus infinitives showed correlation to that level. Additionally Ojemann concluded that the qualitative factors were important to an article's readability, although he could not compute a mathematical correlation for them (Ojemann, 1934:11-32).

#### Dale and Tyler

Dale and Tyler's study (1934) was similar to the work of Ojemann in both content and form.

These authors sought to develop a means by which they could determine the factors influencing the reading difficulty for adults of limited reading ability. In their study they looked at 25 different items to see which had a strong correlation with reading difficulty. The items they investigated could be roughly grouped into the following eight categories: technical words, easy words (which they defined as words common to both Thorndike's first 1000 words and to the list of the International Kindergarten Union), difficult nontechnical words, the type and length of the sentences used (such as compound, complex, or simple), the number of clauses or prepositional phrases, the number of

personal pronouns, the number of monosyllabic words, and other factors (Klare, 1963:46-47). As a result of their investigation Dale and Tyler developed the following regression equation which yielded a correlation of .51 with the criteria:

$$A = -9.4 B - 0.4 C + 2.2 D + 114.4 (+/-9.0)$$

where A was defined as the percentage of adults of third to fifth grade reading ability who could understand a passage, B was equal to the number of different technical words in the passage, C equated to the number of hard non-technical words, and D was the number of indeterminate clauses present (Dale and Tyler, 1934:384-412).

### McClusky

McClusky was the next researcher to expand the scope of readability. In his 1934 studies he used speed of reading tests, rather than comprehension, as an index of a book's readability. McClusky found that "easy" material contained short sentences and simple terminology, while "hard" material contained complex sentences and technical or unfamiliar words (Klare, 1963:206).

Although unique, McClusky's speed of reading tests did not appear to have much influence on future readability studies. The next researchers who had did have such an impact were Gray and Leary.

### Gray and Leary

In 1935 Gray and Leary published a classic work on the subject of readability entitled What Makes a Book Readable. This text was, at that time, the most thorough work on the subject ever printed. As a starting point for researching this book, and in turn for developing their own readability formula, Gray and Leary investigated all previous work on the subject. They consulted with approximately 100 experts in the field as well as over 170 library patrons. From this initial investigation Gray and Leary developed a list of 229 factors which could influence an article's readability. The factors were then classified into four broad categories: context, style of expression and presentation, format, and general organization. Of these, the style section was chosen for further investigation.

As a result of running numerous statistical tests to see which of the factors best correlated with reading score, the researchers developed the following formula:

$$A = -.01029 B + .009012 C - .02094 D - .03313 E \\ - .01485 F + 3.774$$

where A is equal to the average comprehensive score for adults of limited reading ability, B is equal to the number of hard words, C is the average number of personal pronouns, D is the average number of words per sentence, E is the percentage of different words, and F is the number of prepositional phrases. Subsequent research found that this

formula correlated at the .6435 factor with the criteria (Klare, 1963:49).

The last of the readability formulas to appear in the 1930s was the revised Washburne and Vogel formula.

#### Washburne and Morphett

In 1938 Carleton Washburne and Mabel Vogel Morphett amended their original readability formula. These changes were designed with the following purposes in mind: to simplify the computations involved in computing grade levels (without changing the accuracy of the original formula), as well as to compensate for the skewing at the extremes of the grade distributions, which were major problems for the original formula.

The new procedure they developed included the following steps: select a sample of 1000 words, count the number of different words, count the number of uncommon words (those not found in Thorndike's first 1500), and finally count the number of simple sentences in 75 sample sentences. The results obtained were then applied to the following formula

$$A = .00255 B + .0458 C - .0307 D + 1.294$$

where A is equal to grade placement, B is equal to the number of different words, C is equal to the number of different uncommon words, and D is the number of simple sentences (Washburne and Morphett, 1938:355-364).

## Lorge

In 1939 Irving Lorge published the next significant work on the topic of readability. This work, inspired in part by the Gray and Leary formula, is considered important in this field because its formula was the first readability measurement to be used extensively in occupations other than education.

Although the Lorge formula was originally designed to serve as "an estimate of the reading grade at which the average school child will be able to answer about 55 percent of the questions concerning detail, appreciation, import, vocabulary, and concept with adequate completeness and correctness," this formula has never-the-less seen widespread use (Lorge, 1959:1).

The attractiveness of this formula can be attributed to the fact that it required only three elements to compute: the average sentence length, the number of prepositional phrases, and the number of hard words (based on the Dale list). Unfortunately, the original 1939 Lorge formula was found to contain errors, and it was necessary for Lorge to recompute his formula. This recomputation was published in 1943. The revised formula is calculated as follows:

$$A = .06 B + .10 C + .10 D + 1.99$$

where A is the grade placement level, B is the average sentence length in words, C is the number of prepositional

phrases per 100 words, and D is the number of different hard words per 100 words not on the Dale list.

### Kessler

Like Lorge's system, Edward Kessler's readability measurement technique was inspired by the work of Gray and Leary. The Kessler formula, however, was a shortened version of the Gray and Leary formula. His methodology consisted of: selecting ten paragraphs of approximately 100 words each, counting the number of words, sentences, and different hard words in the passages, then calculating the average sentence length in number of words and the number of different hard words per 100 words, and finally comparing those calculated averages with the standards developed by Gray and Leary (Klare, 1963:55).

Kessler's work was the last formula to be developed during the early readability period, a period characterized by experimentation in defining what makes a piece of text readable. Kessler's work was also the last readability formula developed before the arrival of Rudolf Flesch, a researcher who revolutionized the field of readability.

### 3. The Recent Development of Readability Formulas: 1943-1989

The recent development of the readability formula starts in 1943, with the arrival of Rudolf Flesch and his Flesch formula. With this single event the field of readability was dramatically changed. The Flesch formula almost overnight became the standard by which most subsequent readability formulas were either developed or compared. It also served as the source formula for many future examinations on the topic of readability and its relationship to the military publication (the subject of chapter 4).

In this chapter, the Flesch formula and the subsequent research it inspired are examined. Additionally recent research extending the topic of readability are commented on.

#### Flesch

Probably the best known and most referenced researcher in the field of readability is Rudolf Flesch. Flesch's formulas on this topic are widely used in assessing the readability of a variety of texts. The reasons for this extensive use are many, but include the formula's basic simplicity and the fact that Flesch was a master at promoting it. In a series of books and articles Flesch advertised his formula, his views on the importance of

readable writing, and his concept of readability to writers in journalism, business, government, and the military services (Klare, 1963:56).

Flesch's first formula on readability (1943) was revised several times. The first revision was needed because Flesch's formula had been based on errors present in the original Lorge data, data which was absolutely essential for the accuracy of Flesch's computations. The second revision was required because many people thought that the computation of Flesch's formula was too difficult.

In response to these criticisms, Flesch designed a revised estimate of readability (1948) which consisted of two different factors: reading ease (RE) and human interest (HI). To measure the factor of reading ease, Flesch examined randomly selected sample passages, measured the number of syllables (SY) per 100 words, and then measured the average number of words per sentence (ST). He then placed the resulting numbers in this formula:

$$RE = 206.835 - .846 (SY) - 1.015 (ST)$$

The RE value obtained was then correlated with grade level. If the RE score was computed to be between 90-100, the material was considered to be equal to fourth grade level material. A passage which scored between 80-90 was equal to fifth grade level, and a score of between 0-30 was written to the college level (Flesch, 1974:247).

The human interest score Flesch developed indicates the liveliness of a writing style. This score is computed by first counting the number of "personal words" (PW) per 100 words and then the number of personal sentences (PS) per 1000 sentences. The resulting numbers are then applied to the following formula:

$$HI = 3.635 PW + .314 PS$$

If the HI score was between 0 to 10, the writing style was considered to be uninteresting. If the score was from 10 to 20, the style was mildly interesting, and if an article scored 60 or more it was said to be written with a dramatic writing style (Flesch, 1946:195).

#### Dale and Chall

The second most referenced formula in the field of readability can be attributed to the work of Edgar Dale and Jeanne Chall. Their procedure, which was designed to correct certain inadequacies of the original Flesch formula, first appeared in 1948.

Dale and Chall, in structuring their formula, thought that a larger word list would be a better predictor of an article's reading difficulty level (particularly at the upper levels of difficulty) than the Dale 769-word list. They believed that the count of personal references as used by Flesch was an unnecessary and time consuming step, and that a more efficient readability formula could be developed

by using only a word factor and a sentence factor as predictors (Klare, 1963:59-61).

The technique these researchers used for computing their readability formula consisted of: selecting sample passages of the material to be analyzed that contained at least 100 words, computing the average sentence length in words for those passages, computing the percentage of words not included in the Dale list of 3000 words, and then applying the obtained results to the following formula:

$$A = .1579 B + .0496 C + 3.635$$

where A is the reading grade score of a student who could answer 50 percent of the test questions on a passage correctly, B is the percentage of words not present in the Dale list of 3000 words, and C is the average sentence length in words (Dale and Chall, 1948:11-20).

#### Farr, Jenkins, and Patterson

Farr, Jenkins, and Patterson also developed a readability formula (1951) which was a simplified version of the Flesch Reading Ease formula. These authors proposed that the syllable count present in the Flesch formula be replaced by a count of one-syllable words. The rationale for this change was twofold: that it is easier and faster to count one syllable words than all the syllables present, and that the requirement for a knowledge of syllabication on the part of the user would not be needed (Klare, 1963:64).

To use their formula all that was necessary was to accomplish the following three steps: select a 100-word sample from the material to be analyzed, count the number of one syllable words per 100 words, and calculate the average sentence length. Once these steps were accomplished the resulting numbers were applied to the following formula:

$$A = 1.599 B - 1.015 C - 31.57$$

where A was equal to the "new reading ease index," B was equal to the number of one syllable words per 100 words, and C was the average sentence length (Klare, 1963:64).

#### Gunning

Similar to Dale and Chall, as well as Farr, Jenkins, and Paterson, Robert Gunning also revised the Flesch Reading Ease formula (1952). He accomplished this revision by replacing the total syllable count with a count of words having three or more syllables. The procedure for using this formula consisted of determining the average sentence length (in number of words), counting the number of words of three or more syllables to obtain the percentage of hard words, and then adding those two factors together. The resulting sum from this addition was multiplied by .4 to obtain the Fog Index (or the reading grade level required for an accurate understanding of the material) (Klare, 1963:65).

The Fog Index, according to Klare, was presumably designed to be applicable for reading material that ranged in difficulty level from sixth to twelfth grade (Klare, 1963:79). Additional evidence which supports this conclusion comes from Gunning himself, who stated that if an article scored above a twelve on his Fog Index it was in danger of being ignored or misunderstood and should probably be rewritten (Gunning, 1952:38).

#### Taylor

In 1954 Wilson Taylor examined the subject of readability from a innovative perspective. A doctoral student in psychology, Taylor approached the measurement of readability from a psychological mind-set. Borrowing ideas from both Gestalt psychology and information theory, the Taylorian method for determining readability consisted of measuring "the percentage of correct guesses which a test group made when blank spaces were inserted in a prose sample to replace every fifth or sixth word" (Hirsch, 1977:94). He then correlated the number of correct guesses with a reading grade level. Taylor's technique of measuring readability by completing or closing sentences came to be called the "Cloze procedure" (Taylor, W., 1955:464-465).

Subsequently it was found that Taylor's Cloze procedure yielded results which correlated remarkably well not only with traditional readability formula scores, but with

reading comprehension scores as well (Taylor, W., 1957:19-26).

One of the traditional readability formulas with which the Cloze formula showed a high correlation is the Automated Readability Index. This formula/mechanism, invented by R. J. Smith and E. A. Senter, is discussed in detail below.

#### Smith and Senter

In 1967 Smith and Senter created the Automated Readability Index (ARI). This formula/mechanism was designed to automate the computation of a text's readability. The formula portion of the ARI has been revised several times, with the most recent revision occurring in 1970 (Smith and Kincaid, 1970:459). The revised formula is calculated as follows:

$$\text{RGL} = .50 (\text{words/sentence}) + 4.71 (\text{strokes/word}) - 22.43.$$

The mechanical portion consists of an attachment to an electric typewriter. This device tabulates the number of words per sentence and the number of strokes per word. Based on this tabulation an RGL is then determined (Smith and Senter, 1967:abstract).

It is interesting to note, that the Smith and Senter formula marked the end of an era, for during the latter half of the 1950s the widespread interest in readability formulas appeared to wane. However, despite this lessening of

general interest, specific researchers began to examine the applicability of using readability formulas to measure the readability of military publications.

#### 4. Readability Formulas and Their Applicability to the Military Publication

This chapter examines the use of readability formulas as assessment tools for military documents. The material covered is addressed from the following perspective: First, the readability formulas developed exclusively for military use will be explored. Then research examining the applicability of using readability formulas with military documents will be summarized. Finally, articles examining concepts paralleling the subject of readability and its relationship to the military document will be described.

##### Caylor, Sticht, Fox, and Ford

Taking a traditional approach to the topic of readability (1973), Caylor, Sticht, Fox, and Ford focused their research on developing a simple, easy-to-administer readability formula. This formula was designed to predict the reading grade level of U.S. Army job reading materials in a valid and reliable manner (Caylor and others, 1973:V).

The authors believed that it was necessary to develop a new readability formula which could address the uniqueness of Army needs, which were characterized by young adult male readers with low reading grade levels and job reading material containing heavy dosages of technical verbiage and jargon.

As part of the process for developing their formulas, these researchers conducted an extensive literature review on the subject of readability. From that hunt 15 suitable variables were chosen for additional investigation. These variables were grouped under the following categories: (1) sentences, (2) words per sentence, (3) independent clauses, (3) words per independent clause, (5) one-syllable words, (6) difficult words, (7) different difficult words, (8) different words, (9) three-or-more-syllable words, (10) total number of syllables, (11) total number of letters, (12) syllables per sentence, (13) number of letters per sentence, (14) seven-or-more-letter words, and (15) different three-or-more-syllable words (Caylor and others, 1973: 7-8). These variables were tested using correlation techniques. As a result of these tests the following preliminary readability formula was developed.

$$RGL = 20.43 - (.11) (A)$$

where A equals the number of one-syllable words present in a 150-word passage.

This formula was eventually simplified and dubbed the FORCAST formula, named from its authors FORD, CAYlor, and STicht. The FORCAST formula is calculated as follows:

$$FORCAST\ RGL = 20 - A/10$$

where A equals the number of one-syllable words present in a 150-word passage (Caylor and others, 1973:15).

This formula was subsequently validated by examining the intercorrelations among FORCAST, Flesch, and Dale-Chall readability indices and scaled reading grade level scores (Caylor and others, 1973:16).

Kincaid, Fishburne, Rogers, and Chissom

Kincaid, Fishburne, Rogers, and Chissom also sought to develop readability formulas (1975) which would be appropriate for military personnel. Specifically, they used the techniques developed by Caylor and others (1973) to modify existing readability formulas for use with the U.S. Navy technical material.

Of the numerous formulas they examined, the most interesting is the recalculated Flesch Reading Ease formula. This formula stands out because it eventually became the Department of Defense (DOD) standard for calculating the reading grade level of its Technical Orders. This formula, which is known as the Flesch-Kincaid formula, or alternatively as the Kincaid formula, is calculated as follows:

$$A = .39 (B) + 11.8 (C) - 15.59$$

where A equals grade level, B equals words per sentence, and C equals syllables per word (Kincaid and others, 1975:14).

Besides becoming the DOD standard for calculating the readability of Technical Orders, the Kincaid formula was also one of the earliest readability formulas to be

computerized. One of the first researchers to use these newly developed formulas to determine the readability level of Air Force regulations were Hooke, DeLeo, and Slaughter.

#### Hooke, DeLeo, and Slaughter

In 1979 Hooke, DeLeo, and Slaughter attempted to determine the readability of Air Force publications which had been rewritten to supposedly match the reading grade level (RGL) of the intended users. The regulations chosen for investigation had to be suitable not only for FORCAST readability estimation (see Caylor 1973), but for the development of CLOZE tests as well (Hooke and others, 1979:8). In their search for suitable material the authors found seven regulations which met those requirements: Air Force Regulations 4-2, 6-1, 25-5, 39-18, 66-39, 144-1, and 190-23.

After analyzing the readability of these regulations and the relationship to the intended users, the authors determined that many individuals responsible for writing Air Force regulations were not able to use the FORCAST formula to accurately estimate the reading grade level of the publication they had written, nor were they able to achieve the target reading grade level of their intended audience. This was especially true when the target RGL was below the tenth grade. In occupations where the Reading Grade Levels were relatively high, and there was no negative literacy

gap, comprehension of the regulations was at an acceptable level; however, where the RGL of the users was low (<9.5), there did tend to be a literacy gap and thus correspondingly inadequate comprehension (Hooke and others, 1979:15-16).

Hooke and others recommended that writers of Air Force regulations should receive additional training in the use of the FORCAST formula and in techniques to decrease the RGL of their texts. Additionally these researchers concluded that the practical problems of simplifying Air Force material below the tenth grade level might be insurmountable because most publications must contain a large number of fixed polysyllabic terms (Hooke and others, 1979:16-17).

Other authors equally concerned about the problems of writing Air Force material to a particular Reading Grade Level are those individuals assigned to produce Procedural Manuals and Technical Orders.

#### Smith and Kincaid

In 1970 Smith and Kincaid attempted to determine the applicability of using the Automated Readability Index to examine the readability of United States Air Force Technical Orders. Specifically, they sought to assess the value of this instrument as a valid and reliable predictor of the readability of the TOs. They also wished to determine the ease of use of the formula, as well as any limitations that might be present.

Based on their analysis the following four conclusions were drawn: First, ARI is a reliable measurement instrument yielding a test-retest correlation consistently above the .985 level. Second, the validity of the formula is suspect, particularly at differentiating easy from medium versions of material. Third, ARI is easy to use and it appears to be more efficient and economical than traditional manual techniques. Finally, if authors attempts to write material specifically to achieve a low readability score they may in fact degrade the readability of the document (Smith and Kincaid, 1970:457-464).

Johnson, Relova, and Stafford

Johnson, Relova, and Stafford also conducted an investigation (1972) into the relationship between the readability of Air Force procedural manuals and discrepancies involving non-compliance with those procedures. The study was undertaken in response to the United States Air Force's concerns over non-compliance with written policies and procedures. The focus of the investigation was limited due to the large number of publications in existence. Rather than trying to sample all Air Force publications, these investigators chose to focus their research on administrative procedures.

In examining the publications, these researchers had two objectives in mind: to assess the readability gap which

existed between procedural manuals/regulations and their target audiences, and to determine if a relationship existed between the readability gap and the extent of non-compliance with the procedures in those publications (Johnson and others, 1972:12).

The readability formula with which they analyzed the material was the Flesch formula. The reading grade levels of the respective audiences for the various publications were determined by analyzing the data obtained from the Uniform Military Record (UMR). The UMR served as a source document through which Johnson, Relova, and Stafford could determine the reading grade level for any Air Force Specialty Code (AFSC).

As a result of this investigation, Johnson, Relova, and Stafford concluded that the number of errors which occurred when procedural tasks were performed were directly related to the differences between the readability of the procedural documents and the reading ability of the users. They further concluded that this situation was unacceptable and should be remedied.

#### Mockovak

In this often-cited 1974 study Mockovak addressed the concerns of Johnson, Relova, and Stafford. Specifically, he attempted to determine the reading demands of 56 different Air Force career ladders, the average reading grade level of

individuals in those ladders, and the reading demands of different types of training material (included in this broad category were such diverse topics as Career Development Coarse material, Technical Orders, and resident training literature) (Mockovak, 1974:5)

The methodology used to acquire the above information consisted of two steps: applying the FORCAST readability formula to the "training materials" (this step allowed Mockovak to determine to what RGL these materials were written), and procuring the reading grade level scores of Air Force personnel. Unfortunately, because the reading grade level scores of the personnel did not exist, they had to be estimated by applying the Airman's Qualifying Exam (AQE) scores to a regression equation developed by Madden and Tupes (1966).

As a result of analyzing the data obtained from this study, Mockovak concluded that both reading skills and requirements varied widely among different Air Force career fields. Additionally, his research revealed that in approximately one quarter of the Air Force career ladders, the reading requirement of the material for that ladder was more than two grades higher than the reading level of the personnel assigned (Mockovak, 1974:8).

### Kincaid, Aagard, O'Hara, and Cottrell

The approach of Kincaid, Aagard, O'Hara, and Cottrell (1981) to the subject of readability was unique. They described how the computer could be used to assist authors in their efforts to improve the readability of technical manuals and training material. Specifically, they explained how the computer could be programed to identify uncommon words and long sentences. They also tested the computer's abilities to edit difficult words, phrases, and sentences. The computer readability editing system (CRES) that these authors reported on used the Flesch-Kincaid readability formula (also referred to as the Kincaid formula) to assess the readability of technical material. This formula was chosen because it was the Department of Defense standard for calculating readability.

### Kieras

Douglas Kieras also used the computer to investigate the readability of Technical Orders. In a 1985 article entitled, Improving the Comprehensibility of a Simulated Technical Manual, Kieras argues that using a computer-based system to improve the comprehensibility of technical orders makes sense. He claims that the traditional readability formulas (those based on word familiarity and sentence complexity) which had been developed and used over the years are not adequate to address the problems associated with the

rewriting of documents. To solve this dilemma, Kieras recommends using a series of rules he developed called the "comprehensibility rules." These rules, which cover such diverse areas as sentence structure, references, textual coherence, and (4) textual organization, are designed to make the rewriting of technical orders easier.

As evidence for the validity of this methodology, Kieras rewrote technical order passages using his comprehensibility rules; he then compared the time required to read the old "poorly written" passages with the time required to read the rewritten passages. The results of this experiment substantiated the author's contention that the rewritten passages were easier to read. Additional evidence, which corroborates the value of using Kieras' methodology to rewrite TOs, was the improvements in task completion using the rewritten material.

#### Parallel Factors

This section of the thesis is included to provide the reader with vital background information relative to the readability of Air Force documents. The scope of the material presented is broad and covers diverse topic areas including methodologies for assessing the reading grade level of the service member, the effectiveness of readability formulas at predicting comprehension, and the

impact of literacy gaps on reading comprehension scores. The first of the authors examined is William Mockovak.

#### Mockovak

Mockovak's 1974 research attempted to determine the reading requirement level of the training material for different Air Force career fields. Specifically, he examined a number of readability "formulas" to assess their applicability for this task. Included in this examination were: Job Reading Task Tests (not a true readability test but rather a performance assessment technique), the Fog Count, the CLOZE technique, and the FORCAST Formula. The criteria used in choosing which formula to use included: objectivity of the formula, the formula's validity, its ease of use, its preparation costs, and the time constraints associated with running the tests.

As a result of these constraints Mockovak chose to use the FORCAST formula for his analysis of the readability of Air Force technical materials because it was previously used with U.S. Army training literature, it included an effective reading grade level range of 5 - 12.9, it was easy to use, and it required relatively little computational time (Mockovak, January 1974:10).

Another team of investigators who were conducting research on readability in 1974 were Thomas Post and Harold Price.

### Post and Price

Post and Price reported on requirements and criteria which they felt should be incorporated by Navy technical writers to improve the readability and comprehensibility of their works. Specifically, the recommendations given were designed to achieve a reading grade level of around 9. These recommendations, relative to the subject of readability, fell into six general areas.

The first area dealt with the need for creating appropriate paragraph headings. Included in this section were the recommendations that fifty percent of the subparagraphs should have lead-ins or subheadings, and that these headings should be less than five words in length. Additionally, this section stressed the importance of ensuring that all of the material within a paragraph was consistent with the paragraph heading.

The second area Post and Price commented on was that paragraphs should be limited to a few clearly identified topics. Recommendations in this area included writing clear and concise topic sentences, limiting the prose material of a paragraph to three main points, and presenting the material in a tabular form if five or more main points were to be included.

The third area these investigators dealt with was the topic of words per paragraph and words per sentence. The key recommendation given in this area included: limiting

paragraphs to sixty words, limiting sentences to twenty words, changing complex and compound sentences to simple sentences, eliminating prepositional phrases and unnecessary modifiers, writing with an active voice and using "peak stress emphasis" (underline, italics, or other highlighting techniques) when lengthy paragraphs could not be avoided.

The fourth readability area the authors stressed was the importance of eliminating lengthy and unfamiliar words from text. These authors thought that text designed for a reading grade level of 9 should average about 1.5 syllables per word.

The final two areas these researchers commented on were the importance of using pictures when introducing key equipment and the significance of page formats for text readability (Post and Price, 1974:60).

#### Mathews, Valentine, and Sellman

The main purpose of this 1978 study was to determine the reading ability of service applicants and selectees, and to assess what relationship, if any existed between the Armed Services Vocational Aptitude Battery (ASVAB) and reading grade level scores. Many people believed that the ASVAB, due to its heavy emphasis on verbal contents, already indirectly measured reading abilities. This belief was directly tested by these researchers (Mathews and others, 1978:5).

In designing their tests, the authors used both the Gates-MacGinitie Reading Tests Survey D, and the Nelson-Denny Reading Test Form C to establish reading grade level scores for the service members. They then ran multiple correlations between the ASVAB (and various sub-test combinations of the ASVAB) and the Gates-MacGinitie, Nelson-Denny, and the average reading grade level.

As a result of this experimentation, the authors reached three conclusions. The medium Gates-MacGinitie reading grade level of applicants who qualified for the services was 10.2 (10.9 for the Air Force, 10.5 for the Navy, and 9.3 for both the Army and the Marines). The multiple correlations between the three ASVAB subtest combination of word knowledge, numeric operations, and general science, and the Nelson-Denny, Gates-MacGinitie, and the average reading grade levels were .77, .80, and .86. Their research indicated that the ASVAB was effectively screening out most of the service applicants with marginal literacy skills (Mathews and others, 1978:7-11).

#### Kern

In 1980 Kern attempted to answer three specific questions: How effective are readability formulas at predicting comprehension for a targeted grade level? Does rewriting material to a lower readability grade level increase its comprehensibility? How does the requirement to

write to a formula score affect the production of written material (Kern, 1980:2)?

In conducting this investigation Kern examined a number of readability formulas, including the Gunning Fog Index; the Kincaid formula; the Dale, Chall formula; and the Farr, Jenkins, Patterson formula to see how well they predicted reading grade level (RGL). He also analyzed recent readability studies to see if they could help to provide answers to his investigative questions. Based on this research, Kern discovered three answers to his investigative question. All readability formulas were unreliable at predicting the reading skill levels required to understand a passage. Rewriting material to a lower grade level does not necessarily improve its comprehensibility. Requiring a text to be written to a specific grade level score shifts the attention of the author away from trying to communicate and trying to reach a formula.

#### Kniffin, Stevenson, Klare, Entin, Slaughter, and Hooke

The principal focus of this 1980 study was to examine the impact of the "literacy gap" (which is defined as the difference between the reading grade level of the service member and the level of difficulty of the material that the servicemember was required to comprehend) upon the reading comprehension of the service member.

The methodology used by these authors consisted of examining three independent variables: Air Force personnel who had reading grade levels of eight and ten, Air Force job related material (which in this case were career development course (CDC)), written to literacy gaps of 0, -2, and -4, and reading times of 30, 45, and 60 minutes (Kniffin, and other 1980: Abstract). The values assigned to these variables were derived in a number of different ways.

For the career development course material, the reading grade levels were calculated by using the Kincaid formula, which is a modified version of the Flesch Reading ease formula. (This formula is also used by the United States Air Force to compute the reading grade levels for its technical orders).

The service members' RGLs were determined by using the California Achievement Test: Reading Level 4. This test was chosen because norms were available at grade equivalents for grade levels of .6 to 13.6. Additionally, confidence intervals for this test had been determined at the 95 percent, 99.9 percent and 99.99999 percent levels.

After conducting the tests and analyzing the data, these researchers reached numbers of interesting conclusions: literacy gaps produce a small but significant difference in comprehension scores; increased reading time, for the range of times used in the experiment, tends to increase reading comprehension; however, the relation

between reading time increase and comprehension level increase is such that subjects given more time learn less efficiently; and finally, of subjects who expressed a preference, the more readable passage was the one strongly preferred (Kniffin and others, 1980:53).

### Conclusions

Although numerous researchers have examined the applicability of using readability formulas with military publications, the issue is still unresolved. Both dissenters (Kern, 1980) and supporters (Kincaid and others, 1975) of using readability formulas provide powerful arguments justifying their positions.

In terms of today's procedures, the supporters of using readability formulas have seen their arguments prevail. The specifics of the current method for examining the readability of military publications are discussed in the next chapter.

## 5. A Synopsis and an Analysis of Current Readability Applications in the USAF

The problem of readability and its usefulness in military publications has been a concern of the United States government for nearly 40 years. This chapter will analyze current Air Force policy relative to the readability of its publications. This presentation can be divided into two subsections. The first subsection analyzes articles focusing on the readability of regulations. The second subsection examines articles exploring the topic of readability and its relationship to technical orders and procedural manuals.

### Regulations

Two Air Force regulations (AFRs) serve as the primary source documents for the readability of the Air Force regulations. AFR 5-1, Air Force Publication Management Program (April, 1986), explains the general Air Force policies for producing a readable publication. AFR 5-8, Preparing Air Force Publication (9 April, 1986), examines those procedures at a greater depth, and suggests specific techniques for implementing the policy guidance of AFR 5-1.

AFR 5-1 states that for regulations to be readable they must, at a minimum, be written to comply with the plain "English Standards." These standards seek to answer the following 11 questions about the regulation. (1) Is it

primarily written in the active voice? (2) Is the style used by the text uncluttered? (3) Are the sentences clearly constructed and grammatically correct? (4) Do the sentences average fewer than 21 words? (5) Are the sentences composed of simple, familiar words or abstract words, unnecessarily technical words and jargon? (6) Are there illogical or inconsistent shifts in the point of view (tense, person, or voice) within a paragraph? (7) Is the material presented in a logical sequence? (8) Is each paragraph limited to one topic? (9) Is each paragraph as brief as possible? (10) Are there as many main paragraphs as possible rather than drawn-out subparagraphing? (11) Are the titles for parts, chapters, sections, and paragraph descriptive and are they designed to ensure that the issue of readability is considered in the writing of any regulation?

Air Force Regulation, (AFR) 5-8, Preparing Air Force Publications, is the best source document available to the project officer who prepares, manages, reviews, approves, or uses Air Force publications. This regulation not only provides general guidelines for improving the readability of Air Force regulations, but it also gives specific recommendations to authors as to how they can produce a more understandable publication. Unfortunately, because this information is scattered throughout the text of this regulation, it is often difficult to find. To simplify this procedure, pertinent areas will be summarized below.

Section 2-31, entitled Improving Readability, provides two general recommendations for obtaining a more readable writing style. The first recommendation is to replace multisyllabic words with shorter words. The second recommendation states that in order to achieve a more readable text, one should simply rewrite the publication. Nowhere in this section is it mentioned that the topic of readability is discussed elsewhere in the regulation.

Section 2-3, Preparing the First Draft, argues that traditional readability factors should be considered in writing regulations. This section emphasizes the importance of using the following factors to achieve a readable writing style: (1) language familiar to the intended users, (2) short sentence and paragraph structure, and (3) unambiguous language. Additionally, and perhaps most importantly, this section directs the reader to attachment two of the regulation for more information.

Attachment 2, entitled Procedures for Reviewing and Editing Drafts, is divided into a number of different sections. Section C, which examines the writing style of Air Force Regulations, is of particular interest to the readability researcher. This section has been subdivided into a number of topics, three of which deal directly with the subject of readability. These pertinent topic areas include: (1) sentence and paragraph length, (2) active

voice, and (3) techniques for improving the readability of regulations.

The first section addresses the subject of sentence and paragraph length. It recommends that sentences which make up the paragraphs of regulations be no more than 20 words long. It also suggests that authors keep their paragraphs short (preferably to four or five sentences) so that the readability of those paragraphs can be substantially improved.

Section two advocates using the active voice when writing to improve the understandability of regulations. Active voice is more natural and direct than the passive voice, and it is easier for the reader to comprehend information presented in this format.

The final section deals with other techniques that can be used to improve the readability of regulations. These techniques consist of: substituting one-syllable words for longer words (see appendix number one for a sample of these proposed substitutions), writing directly to the reader by attempting to use the second person, being concise, not hiding the main ideas in the body of a paragraph, not using smothered verbs, not splitting predicates with prepositional phrases and clauses, not using the slash ("/") to combine ordinary terms, and using parallel construction when possible.

Additionally, Change 1 to attachment 2 provides a listing of words designed specifically to produce a more readable publication. A sample listing of these words is provided in Appendix A.

Although the Air Force provides extensive guidance on techniques for producing readable regulations, little research exists which examines the effectiveness of that guidance or the success that Air Force writers have had in implementing that guidance. One notable exception to this situation is the 1979 study of Hooke, DeLeo, and Slaughter, discussed in chapter 4.

In general, the Air Force approach for ensuring the readability of its non-Technical Order publications seems uncertain. Information on this topic is scattered among numerous regulations, and the advice that is given does not appear to have been empirically tested.

Additionally, this researcher found no official justification for the recommendations that were given, nor any precise evidence indicating how well those recommendations were being followed. It is interesting to note that at one time the Air Force required its regulations to meet a readability standard. Why this requirement was abandoned, however, is not clear. The Air Force guidance on producing readable Technical Orders, however, is very clear.

### Procedural Manuals/Technical Orders

The problems of writing Technical Orders (TOs) and procedural manuals are more complicated than those of any other document. Problems arise not only because technical information itself is expanding at a tremendous rate, but also because it comes from diverse sources. The scientist or engineer who creates the product, as well as the people who manufacture, inspect, service, and use the product possess complex information which must to be included (AECMA, 1986:iii). Additionally, this information must be written in such a way that it is readable by its target audience. To ensure that this requirement is met, the U.S. Air Force mandates that its technical orders and procedural manuals adhere to the requirements specified in AFR 8-2, Air Force Technical Order System (17 April, 1987).

AFR 8-2, the Air Force's governing document on Technical Orders, requires that numerous actions occur prior to the publishing of the Technical Order. Specifically, the process of producing a readable TO begins with the contractor agreeing to write the narrative material of the Technical Order to the reading grade level (RGL) of the target audience. Excluded from this RGL requirement, however, are TOs that contain "little if any narrative" text, such as:

- (1) Aircraft Flight Manuals (-1 Series)
- (2) Job Guide Manuals (-2 JG Series)

- (3) Illustrated Parts Breakdown (IPB) Manuals (-5 Series)
- (4) Basic Weight Checklist and Loading Data Manuals (-5 Series)
- (5) Cargo Aircraft Loading Manuals (-9 Series)
- (6) Non-Nuclear Munitions Delivery Manuals (-34 Series)
- (7) Acceptance and/or Functional Check Flight Manuals, (-6CF-1 Series)
- (8) Work Unit Code Manuals (-06 Series)
- (9) List of Applicable Publications (LOAPS) (-01 Series)
- (10) Aircraft Inspection Manuals and Associated Workcards/Worksheets (-6 and 6WC/-6WS Series)
- (11) Wiring/Schematic Diagram Manuals.

Additionally, AFR 8-2 directs contractors to identify which Air Force Specialty Code (AFSC) would be required to use the TO, to determine their RGL, and to write the Technical Order to that level. This regulation also states that information regarding the RGL for each AFSC is available in MIL-STD-1752 (Military Standard Reading Level Requirements for the Preparation of Technical Orders). Unfortunately, when this researcher tried to verify that information by obtaining a copy of MIL-STD-1752, he found that it had been deleted. The notice cancelling it stated that Technical Orders should be written to an RGL of 9. Additionally, the cancellation notice recommends using the Association Europeene Des Constructeurs De Materiel Aerospatial (AECMA) document number PSC-85-16598 (1986) entitled AECMA Simplified

English: Guide for the Preparation of Aircraft Maintenance Documentation in the International Aerospace Maintenance Language as a tool to assist the writers of technical orders in their efforts to achieve a ninth grade reading level (MIL-STD-1752 Notice 1, 1988). In assessing the utility of this document as an aid to writing Technical Orders it is important to understand the document's origins.

AECA-PSC-85-16598 was born out of a need in the aerospace industry for clear and concise communication of complex maintenance information. As a starting point for producing this document, the Association of European Airlines asked airplane manufacturers to investigate readability criteria for maintenance documentation within the civilian aircraft industry. The response they received was overwhelming, with companies from Italy, France, West Germany, England, Holland, and the United States all choosing to work on this project (Appendix B provides a complete list of participating companies).

The output this combined effort produced is unique for a number of reasons: it establishes one word for a particular notion, thus eliminating the problem of different words being used to define the same thing, it rigidly defines the meaning of the word, and it establishes a set of rules designed to simplify any author's writing style.

The rules developed to achieve this simplified writing style fall under eight broad categories: (1) words, (2) the

grouping of words, (3) verbs, (4) sentences, (5) procedures, (6) descriptive writing, (7) warnings and cautions, and (8) punctuation (AECMA, 1986:1-0-1 through 2-2-93). These rules were designed not to achieve a specific reading grade level, but rather to simplify an author's writing. However, because the Air Force requires its technical manuals and orders to be written to a ninth grade level (MIL-STD-1752 Notice 1, 10 July, 1988) it was necessary to consult MIL-M-38784B (16 April, 1983) Military Specification Manuals, Technical: General Style and Format Requirements to see how this task is supposedly achieved.

MIL-M-38784B was designed to be used by all departments and agencies of the Department of Defense (DOD). Its primary purpose is to establish the general style and format requirements for the preparation of standard technical manuals and changes thereto (MIL-M-38784B, 1983:1). Included in the general style category is the topic of readability. This document requires that "technical publications be written at a Reading Grade Level (RGL) commensurate with the capability of the target audience" (MIL-M-38784B, 1983:15). It states that when tested, these technical documents must not have an overall grade level which exceeds the appropriate RGL by more than 1.0 grade levels. Additionally, the grade level of each tested sample is not to exceed the appropriate RGL by more than 3.0 grade levels. To ensure that RGL requirements of this

specification are met, this document mandates that a validation check occur. The specific nature of this extensive check can be found in Appendix C. Unlike the topic of readability and regulations, the topic of readability and its relationship to the military procedural manual/Technical Order has been extensively investigated.

Now that the procedures for producing a readable technical order have been clearly provided, the next step is to examine the Air Force's rationale for following those procedures. The Air Force selected the ninth grade as the targeted RGL because most individuals entering the Air Force had at least this RGL, and for those that did not, remedial reading training programs are available at most bases to increase reading skill levels (Mockovak, 1974:4). It was also thought to be more economical to write to a standard ninth grade level as opposed to reevaluating the reading requirement levels for various Air Force Specialty Codes (AFSC).

The Air Force's stated rationale for excluding certain series of Technical Orders from meeting the reading grade level requirement is based on the assumption that those TOs contain little if any narrative text. Because text is necessary to compute a RGL for a document, those TOs are not considered suitable for evaluation according to the Flesch-Kincaid readability formula.

The Air Force decision to recommend the use of AECMA to achieve a more readable writing style for its Technical Orders appears to be based on a number of diverse factors including the fact that AECMA was endorsed by most of the free world's major commercial aerospace companies (AECMA, 1986). Because AECMA provides specific rules for simplifying writing style, this document was viewed, by the Air Force, as a valuable first step in standardizing their Technical Orders.

The DOD elected to use the Kincaid readability formula to assess the readability of its Technical Orders for a number of reasons. The formula was developed using military personnel as subjects and using military technical materials, and it was thought to have appropriate norms. Flesch type formulas (which include the Kincaid formula) have been used extensively in examining the issue of readability, and thus a greater number of people are likely to be familiar with their application. The word and syllable counts required to use the Kincaid formula can be easily determined, and finally, the Kincaid formula can be used to compute the reading grade level of a document either manually or automatically without too much inconvenience or cost (Kniffin, 1981:3).

The technique for achieving readable technical orders and the justifications for using this technique at first

glance seem solid. However, upon close examination numerous potential problem areas begin to appear.

The first of these potential trouble areas is the requirement that the Technical Orders be written to a ninth grade reading level. Numerous researchers have indicated that the requirement is unnecessarily restrictive and may be extremely costly to determine (Johnson and others, 1972:56; Kniffin, undated:3-4). Additionally, this researcher found no studies examining the impact on the readability of a document if the material were written to a RGL substantially below the RGL of its targeted audience. It is conceivable that a lower RGL could make the material too simple to the reader and thus less valuable as a tool for transferring information.

The rationale for excluding certain types of Technical Orders from meeting the ninth grade reading level requirement also seems sound; however, once again a close examination of the logic behind this choice reveals problems. The first and most obvious discrepancy is the incorrect fundamental assumption on which the decision rests, the assumption that -1 Series of Technical Orders contains little if any narrative text. This assumption is obviously wrong, as the examination of any aircraft -1 clearly demonstrates.

Another possible trouble area that contractors face in ensuring that their Technical Orders are readable is the

recommendation to use the AECMA Guide for the Preparation of Aircraft Maintenance Documentation in the International Maintenance Language as a guide to reach the ninth grade reading level. The problem with this advice is twofold; first, AECMA was designed specifically as an aid for writing Technical Orders relating to the aerospace industry, and it may not be applicable for other Air Force Technical Orders. Secondly, although the recommendations that AECMA makes appear logical, they do not seem to have been empirically tested.

The last step that the Air Force requires in order to check the readability of its Technical Orders contains at least three potential problems. The first problem is that the Kincaid formula was developed as a result of studies on Navy personnel and Navy Technical Orders, and it may not be an appropriate test for the readability of Air Force material. Secondly, even if future studies validate the use of the Kincaid formula, the Air Force's decision to exclude certain multi-syllabic technical words from calculation when computing the Technical Order's reading grade level invalidates the use of this formula, thus causing the reading grade level score to appear lower than it actually is. Finally, Kincaid's (and others) 1975 article shows the original Flesch Reading Ease formula calculated in a different manner than that found in any other source (Klare, 1963:59; Flesch, 1974:247-251). The formula as displayed by

Kincaid and others (1975) is as computed as follows:

$$RE = 206.835 - 1.015 (\text{words/sentence}) - .836 (\text{syllables}/100 \text{ words}).$$

However, the formula that appears in Flesch (1974) is slightly different. This formula is calculated as follows:

$$RE = 206.835 - 1.015 (\text{words/sentence}) - .846 (\text{syllables}/100 \text{ words}).$$

The impact of the .01 difference between the two formulas is yet to be determined, although logic would indicate that this influence is probably minimal.

### Conclusions

The recent decisions to change the procedures for determining the Reading Grade Levels of Technical Orders, as well as the decision to exclude regulations from meeting readability requirements, suggest that there is some bewilderment about the usefulness of readability formulas within the Department Of Defense. This confusion is further evident by the recommendation to adopt the practices indicated in the AECMA document. This recommendation appears to imply that semantics, as well as syllables per word and words per sentence, are all important in determining a publication's readability.

Additionally, the technique employed to determine the Reading Grade Level of TOs bears reevaluation in lieu of the findings in this chapter.

## 6. Conclusions and Recommendations

### Conclusions

Based on information presented in the previous chapters it is reasonable to conclude that the Air Force does not have a clearly defined methodology in place which can confidently assure the readability of its publications. The current Air Force procedures employed to address this problem are inadequate. Revaluation needs encompass both the readability of Technical Orders and the readability of other Air Force publications.

Regarding the topic of readability of its Technical Orders, the Air Force should reexamine the requirement to write the material to a ninth grade reading level. To automatically assume this requirement will save money without empirically testing this assumption seems unwise. It is perhaps additionally imprudent not to investigate the impact of producing technical reading material significantly below the reading grade level of the intended user.

The Air Force rationale for excluding certain Technical Orders from meeting reading grade level requirements also needs to be reexamined. This requirement, which is based specifically on the belief that these TOs contain little if any narrative text, clearly does not apply to the -1 series of Technical Orders, and may not in fact apply to the other excluded documents as well.

Another area that the Air Force should reconsider is the recommendation to use AECMA as a tool to assist the writers of Technical Orders in their efforts to achieve a ninth grade reading level. This suggestion is premature for a number of reasons. First, AECMA was designed to simplify a writing style, not to achieve a specific reading grade level. Although this document can be used as an effective aid to writing to a 9 RGL it, does not guarantee those results. In fact many experts on readability caution against writing to a formula, as this technique often produces a document which is even less readable (Kincaid and others, 1967:7).

Additionally, because AECMA was originally developed to be used in the aerospace industry, it contains terminology peculiar to that industry. Therefore the suggestion that it is applicable to all Air Force TOs is unsubstantiated and bears further investigation.

Equally unsubstantiated is the readability formula that the Air Force uses (the Kincaid formula). This formula should be evaluated to determine if it is applicable to Air Force Technical Orders and to ascertain the magnitude of the impact of the Air Force decision to exclude certain technical words from being calculated (by the formula) when computing a text's reading grade level. The discrepancy which exists between the original Flesch formula, as reported by Flesch (1975), and the slightly different

version of the formula used by Kincaid in deriving his formula should also be resolved.

Although the Air Force policy for establishing the readability of its TOs appears inadequate, at least a formally stated policy exists. This is not the case with regulations and other Air Force publications. For these documents the Air Force advice on obtaining a readable text is poorly structured and difficult to find. The guidance that is given appears sound, but unfortunately it does not seem to have been empirically tested.

Conceivably the confusion that is apparent in the methodology and logic of applying readability formulas to Air Force documents is indicative of the effectiveness and values of readability formulas as a whole. While it would be improper to deny that readability formulas have provided meaningful assistance in the area of producing a readable document, it seems clear that other aspects of style are important and should be considered when writing to produce a readable document (Vaughan and Ferkinhoff, 1989:8).

To rectify this problem, and the others previously mentioned, additional research should be conducted. This research may be costly but the results obtained might easily make the investment worth while.

### Recommendations

Specific recommendations for future research include:

1. Determining if the ninth grade reading level is really the most desirable level for Air Force Technical Orders to be written. Included in this analysis should be both cost analyses, and more importantly, effectiveness analyses.
2. Reassessing the decision to exclude certain Technical Orders from meeting reading level requirements.  
Certainly any document which affects aircraft operations, aircraft inspection, or munitions handling needs to be written in a readable form.
3. Conducting a study to determine if the Kincaid formula is really the best evaluative tool for determining the readability of Air Force Technical Orders.
4. Analyzing the effectiveness of using AECMA as a tool for simplifying the rewriting of material to a specified grade level.
5. Developing guidance relative to the readability of regulations and other military documents.

Appendix A: AFR 5-8 Listing of  
Simplifying Words and Phrases

INSTEAD OF THIS	TRY THIS
accomplish	do
accomplish (a form)	prepare, complete, produce, fill in, make out, carry out
accordingly	so, therefore
achieve the maximum results	get the most from
actual	real
adjacent to	next to
advise	tell, inform
afford an opportunity	allow, let
after a thorough review of your report, this headquarters approves the recommendation contained therein	we approve your recommendation
all information will be furnished promptly to the commander	inform the commander promptly
all these items will be broken down in separate categories	list these items by category
along the lines of	like, similar
ameliorate	improve
and/or	or, and (not both)
append	add, attach
appropriate	suitable, pertinent, relevant, proper, right or delete it)
are desirous of	want to

are in receipt of	received
as a means of	to
as prescribed by	under
as to your request, letter	about your request, letter
ascertain	find out, learn
assist	help, aid
assure	to make sure, ensure, insure, (the correct meaning is none of these, but the word is often misused for one of these)
at a later date	later
at all times	always
at an early date	soon, shortly (or give the date)
at the present time	now, currently, at present, presently
at this time	now
attached hereto (or herewith)	attached, attached to this, here are
attempts to	tries
attention is invited to	see, please note
augment	increase, extend, enlarge, expand
biannual	twice a year
biennial	once in two years
by means of	by, with
by virtue of	because
capability (has the capability to)	can

care should be taken	be careful, take care
close proximity	close, near
cognizant of	aware of, know, have knowledge of, under- stand, comprehend, appreciate, alert to
combine	join
commence	begin
commensurate	equal to, corresponding to, to agree with
comply with	carry out, meet, satisfy, execute
concerning	about, on
conclude	end, close
consider favorably	approve
consideration should be given to the fact that	note that
constitute(s)	are (is)
contained in	in
containing	has, that have, etc.
contains a	has
deemed to be	considered
detailed	more, full
determine	decide, find
develop	make, grow
disseminate	issue, get out, circulate, distribute
do not give rise to	do not apply
due in large measure	because, due to
due to the fact that	because of, since, hence

during the periods when	when
echelons	levels
effect an improvement	improve
employ	use
ensure	make sure
equitable	fair
establish	set up
every effort will be made	I or we will try
evidences	facts
evident	clear
expedite	hasten, speed, do promptly, make easy
expense	cost, fee, price
experience has indicated that	learned
explain	tell, show
facilitate	ease, clear, help, aid, free, make easy
final	last
finalize	complete, finish, conclude, settle
for the purpose of	for, to
for the reason that	since, because
forward	send
fullest possible extent	fully, to the maximum
functions	works
gained from the following source	obtained, learned
generate	produce
give consideration to	consider

govern	rule
held a meeting	met
hereby	by this
hereby advise	advise, advise by this
herein, hereinafter	here
herein set down	listed here, stated here

#### LISTING OF NONSEXIST TERMS FOR AIR FORCE PUBLICATIONS

INSTEAD OF	USE
chairman	chairperson; chair; head of the committee
clergyman(en)	clergy member(s); member(s) of the clergy
Congressman(en)	member(s) of Congress; Congressmen and Congresswomen
crewman(en)	crewmembers
draftsman(en)	drafter(s)
foreman(en)	supervisor(s); superintendent; shop chief(s)
journeyman(en)	journey worker(s)
juryman(en)	jury member(s); member(s) of the jury
layman(en)	lay person(s)
man-hour(s)	work hour(s)
mankind	human race

manmade	machine made; synthetic; artificial; simulated
manned aircraft	occupied aircraft; piloted aircraft
manning	staffing
National Guardsman(en)	member(s) of the National Guard
policeman(en)	police officer(s)
pressman(en)	press operator(s)
repairman(en)	repairer(s)
serviceman(en)	servicemember(s); service - men and servicewomen
spokesman(en)	spokesperson
steward(s); stewardess(es)	flight attendant(s); cabin attendant(s)
unmanned aircraft	unoccupied aircraft; pilotless aircraft; remotely piloted vehicle
undermanned	understaffed
watchman(en)	watchguard(s)
wireman(en)	wirer(s); wireworker(s)
workmen's compensation	worker's compensation

(extracted from AFR 5-8 Attachment 2, 1985:57-61)

APPENDIX B: AECMA Participants  
COUNTRIES/COMPANIES  
PARTICIPATING IN THE CREATION OF AECMA

- |                      |   |
|----------------------|---|
| 1. Airbus Industries |   |
| 2. France            | Aerospatiale  |
| 3. Italy             | Aeritalia<br>Aermacchi  |
| 4. Netherlands       | Fokker  |
| 5. United Kingdom    | British Aerospace<br>Westland Helicopters   |
| 6. U.S.A.            | Garrett<br>General Electric<br>Goodyear Aerospace<br>Grumman<br>Hamilton<br>Lockheed<br>McDonnell Douglass<br>Pratt and Whitney<br>Sundstrand<br>Westinghouse |
| 7. West Germany      | MBB   |

(extracted from AECMA, 1963:9)

ADDITIONAL ORGANIZATIONS  
INVOLVED IN THE DISTRIBUTION OF AECMA  
DOCUMENT # PSC-85-16598

1. National Associations who are members of AECMA, and all their member companies.
2. Members of Association of European Airlines (AEA).
3. Members of Aerospace Industries Association of America (AIA).
4. Members of Air Transport Association of America (ATA).
5. Members of International Coordinating Council of Aerospace Industries Associations (ICCAIA), not included in categories 1 to 4 inclusive.
6. Ministries of Defense of the member countries of AECMA.
7. The Department of Defense of the U.S.A.

(extracted from AECMA, 1963:unnumbered page)

Appendix C: Computational Methodology  
for Determining the RGL of Air Force TOs

(extracted from MIL-M-38784B, 1983:38-40)

4.4.1. Sample selection. Samples of text shall be analyzed for readability. Select samples as follows:

- a. Count number of pages of text in publication. The count shall include all full and partial pages that contain text in the form of consecutive sentences. The count shall not include pages containing only illustrations, tables, lists, etc. Record number of text pages.
- b. The basic number of samples is determined by the following:

<u>NO. OF TEXT PAGES</u>	<u>DIVISOR</u>  <u>DIVIDE BY "N"</u>	<u>BASIC NO.</u>  <u>OF SAMPLES</u>	
		<u>MIN</u>	<u>MAX</u>
90 and above	10	9	30
54 to 89	9	6	9
32 to 53	8	4	6
1 to 31	6	2	4

- c. Divide number of text pages by appropriate divisor, "N". Round off quotient to the next lowest whole number. For example, quotients of 17 and 17.7 shall both be rounded off to 17. This quotient shall equal basic number of samples to be analyzed.
- d. For publications that are less than 12 pages, randomly select two samples and mark them for analyses.

e. For publications that are 12 pages or more, randomly select a number between one and "N." The number selected shall be marked as first page of text to be analyzed. Starting at selected page, mark every "Nth" page of text to end of publication. The marked pages shall identify starting points for remaining basic samples to be analyzed.

f. Check marked pages to verify that at least one sample has been selected for each chapter of the publication. If any chapter has been missed, randomly select one text page from that chapter and add it to the basic samples to be analyzed.

4.4.2 Raw data collection. For each sample marked, raw data must be collected. Data collection will consist of counts of the numbers of words, sentences and syllables in each sample. The size of each sample is based on the number of words to be analyzed.

4.4.2.1 Word Count. Most samples will be slightly more than 200 words; in some cases, samples will be smaller. Word count samples shall be determined as follows:

a. Samples shall start at the beginning of the first full paragraph on each marked sample page. If sample falls on a page containing procedural instructions, start sample at beginning of first full sentence on page. Headings, captions, and paragraph titles shall not be counted in the sample.

b. For each sample, count all words up to the end of sentence containing the 200th word. If the marked sample page is less than 200 words, sample can be extended to next page of text; but, do not extend sample into a new chapter or text pertaining to a completely new subject.

c. Count as a word all numbers, letters, symbols, and group of letters surrounded by white spaces. Hyphenated words and contractions count as one word. For example, each of the following count as one word: couldn't; GFE; i.e.; 52,000; 13-inch; +25°F.

d. Record number of words in each sample.

4.4.2.2 Sentence count. For each sample, count number of sentences as follows:

a. Count all sentences in sample including sentence that contains the 200th word.

b. Count as a sentence each unit of thought that can be considered grammatically independent of another sentence or clause. A period, question mark, exclamation point, and semi-colon usually denote independent clauses and thus mark the end of a sentence.

c. Record number of sentences in each sample.

4.4.2.3 Syllable count. For each sample, count number of syllables as follows:

a. For most words, count syllables the way the word is normally pronounced aloud. For example: at is one syllable, maintain is two syllables, area is three

syllables, panoramic is four syllables, and recuperator is five syllables.

b. Count all numbers as one syllable. For example, 5.1, 65, 300 all count as one syllable. However, if a numeric expression contains several numbers separated by hyphens, count each number as a syllable. For example, in the expression TM 9-1025-240-10, 9-1025-240-10 is counted as four syllables.

c. Acronyms and abbreviations are counted as one syllable unless they actually spell out a word of more than one syllable. For example, Hz and DVM each count as one syllable but TRADOC and ARRCOM each count as two syllables.

d. Record number of syllables in each sample.

#### 4.4.3 Grade level calculations.

4.4.3.1 Overall grade level. The Overall Grade Level (OGL) of a publication is calculated as follows:

a. Add up total number of words from all samples combined. Record total.

b. Add up total number of sentences from all samples combined. Record total.

c. Add up total number of syllables from all samples combined. Record total.

d. Calculate the average sentence length. Divide total number of words by total number of sentences. Round off quotient to the nearest one-hundredth. Record quotient.

e. Calculate the average number of syllables per word.  
Divide total number of syllables by total number of words.  
Round off quotient to the nearest one-hundredth. Record  
quotient.

f. Calculate the Overall Grade Level (OGL) of publication  
by the following formula:

$$\text{OGL} = 0.39 (\text{Avg words/sentence}) + 11.8 (\text{Avg syllables/word}) - 15.59$$

Round off the OGL to the nearest one-tenth

4.4.3.2 Sample grade levels. Calculate the GL of each  
sample as follows:

a. Calculate the average sentence length. Divide number of  
words in sample by number of sentences in sample. Round off  
quotient to the nearest one-hundredth.

b. Calculate the average number of syllables per word.  
Divide number of syllables in sample by number of words in  
sample. Round off quotient to the nearest one-hundredth.

c. Calculate the Grade Level (GL) of each sample by the  
following formula:

$$\text{GL} = 0.39 (\text{Avg words/sentences}) + 11.8 (\text{Avg syllables/word}) - 15.59$$

Round off each GL to the nearest one-tenth

## Bibliography

- Association Europeene Des Constructeurs De Materiel  
Aerospatial. AECMA Simplified English Guide for the  
Preparation of Aircraft Maintenance Documentation in  
the International Aerospace Maintenance Language.  
Document PSC-85-16589. Paris, France 1986.
- Bear, M.V., The Length of Word as an Index of Difficulty in  
Silent Reading. Unpublished Master's thesis,  
University of Chicago, 1972.
- Caylor, John S. and others. Methodologies for Determining  
Reading Requirements of Military Occupational  
Specialties, March 1973. Contract DAHC 19-73-C-0004.  
Presidio, Monterey CA. (AD 785-872).
- Chall, Jeanne S., Readability: An Appraisal of Research and  
Application. Columbus: The Bureau of Educational  
Research, Ohio State University, 1958.
- Dale, Edgar and Jeanne Chall, "A Formula for Predicting  
Readability," Education Research Bulletin, 27:11-20,  
(January 1948).
- Dale, E. and R.W. Tyler, "A Study of the Factors  
Influencing the Difficulty of Reading Materials for  
Adults of Limited Reading Ability," Library  
Quarterly, 4:384-412 (July 1934).
- Department of the Air Force. Air Force Personnel Testing  
System. AFR 35-8. Washington: HQ USAF, 25 April  
1983.
- Department of the Air Force. Air Force Publication  
Management Program. AFR 5-1. Washington: HQ USAF,  
9 April 1984.
- Department of the Air Force. Air Force Technical Order  
System. AFR 8-2. Washington: HQ USAF, 17 April 1987.
- Department of the Air Force. Military Standard Reading  
Level Requirements for Preparation of Technical Orders.  
MIL-STD-1752 Notice 1, 19 July 1988.
- Department of the Air Force. Numerical Index of Standard  
and Recurring Air Force Publications. AFR 0-2.  
Washington: HQ USAF, 3 July 1989.
- Department of the Air Force. Preparing Air Force  
Publications. AFR 5-8. Washington: HQ USAF, 27 April  
1984.

- Department of the Air Force. Preparing Written Communications. AFR 10-1. Washington: HQ USAF, 24 March 1985.
- Department of the Air Force. The Tongue and Quill. AFP 13-2. Washington: HQ USAF, 2 January 1985.
- Department of Defense. Comprehensibility Standards for Technical Manuals. DOD-STD-1685 (SH). Washington: Government Printing Office, 10 October 1978.
- Department of Defense. Military Specification Manuals, Technical: General Style and Format Requirements. Mil-M-38784B, 16 April 1983.
- Dolch, E.W. "Vocabulary Burden," Journal of Educational Research, 17:170-183 (March 1928).
- Flesch, Rudolf. The Art of Plain Talk. New York: Harper and Row Publishers, 1946.
- Flesch, Rudolf. The Art of Readable Writing (25th Anniversary Edition). New York: Harper and Row Publishers, 1974.
- Gray, W.S. and Leary, B.E. What Makes a Book Readable... An Initial Study. Chicago: The University of Chicago Press, 1935.
- Gunning, Robert. The Technique of Clear Writing. New York: McGraw-Hill, 1952.
- Hirsch, E.D. Jr. The Philosophy of Composition. The University of Chicago Press 1977.
- Hooke, Lydia R. and others. Readability of Air Force Publications: A Criterion Referenced Evaluation. Report Number AFHRL-TR-79-21. (AD-A061 008). Lowry AFB CO: Technical Training Division, Air Force Human Resources Laboratory, September, 1979.
- Huckin, Thomas N. "A Cognitive Approach to Readability", in New Essays in Technical and Scientific Communication: Research, Theory, Practice. edited by P.V. Anderson, R.J. Brockman, and C.R. Miller. Bagwood Publishing Comp., Inc 1983.
- Johnson, G.R. "An Objective Method of Determining Reading Difficulty", Journal of Educational Research, 21:283-287 (April 1930).

- Johnson, Wing Commander Royal Australian Air Force, Keith H., and others. An analysis of the Relationship Between Readability of Air Force Procedural Manuals and Discrepancies Involving Non-Compliance With The Procedures. MS, Thesis, AFIT/SLSR-25-72B. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, August 1972 (AD-750 917).
- Kellner, Robert S. "Writing for the Government," Research in Technical Communication, edited by Michael G. Moran and Debra Journet. Westport CT: Greenwood Press, 1985.
- Kern, Richard P. Usefulness of Readability Formulas for Achieving Army Readability Objectives: Research and State of the Art Applied to the Armys Problems. Report (AD A 086 406) U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Benjamin Harrison, IN, January 1980.
- Kessler, E. "The Readability of Selected Contemporary Books for Leisure Reading in High School Biology," Science Education, 25:260-264 (October 1941).
- Kieras, David E. Improving the Comprehensibility of a Simulated Technical Manual, June 1985. Contract N0014-84-K-0729. Personnel and Training Research Programs, Office of Naval Research, Arlington VA, (AD-A157482).
- Kincaid, Peter J. and others. "Computer Readability Editing System," IEEE Transactions on Professional Communication, Vol. PC-24 No. 1, March 1981.
- Kincaid, Peter J. and others. Derivation of New Readability Formulas (Automated Readability Index, Fog Count and Flesch Reading Ease Formula) For Navy Enlisted Personnel, February 1975. Contract N61339-74-D-0022. Georgia Southern College (AD/A-006-655).
- Kincaid, Peter J. and others. Use of the Automated Readability Index to Assess Comprehensibility of Air Force Technical Orders, November 1967. Technical Report SEG-TR-67-17. Systems Engineering Group Aeronautical Systems Division Wright-Patterson Air Force Base OH (AD824702).
- Kniffin, Douglas J. The New Readability Requirements for Military Technical Manuals Senior Data Engineer Westinghouse Electric Corporation, Hunt Valley MD, unpublished research report, 1981.

Kniffin, Douglas J. and others. Operational Consequences of Literacy Gap. Report AFHRL-TR-79-22, (AD-A084782). Lowry Air Force Base CO: Technical Training Division, Air Force Human Resources Laboratory, May 1980.

Lamoreaux, Capt. Melvin E. A Synthesis of Research on Color Typography, and Graphics as They Relate to Readability. MS thesis, AFIT/GLM/855-40. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright Patterson AFB OH, September 1985 (AD-A: 161-340).

Lorge, Irving The Lorge Formula for Estimating Difficulty of Reading Materials. Teachers College Press, Teachers College, Columbia University NY. 1959.

Lorge, Irving "Word Lists as Background for Communications", Teachers College Record, 45:543-552, (May 1944).

Mathews, John J. and Bennie Roach W. Reading Abilities Tests: Development and Norming for Air Force Use. Report Number AFHRL-TR-82-26, (AD-A125.913). Brooks AFB TX: Manpower and Personnel Division, Air Force Human Resources Laboratory, February 1983.

Mathews, John J, and others. Prediction of Reading Grade Levels of Service Applicants From Armed Services Vocational Aptitude Battery. Report Number AFHRL-TR-78-82, (ADA 063 656). Brooks AFB TX: Personnel Research Division, Air Force Human Resources Laboratory, December 1978.

Mockovak, William P. An Analysis of Air Force Reading Improvement Program: Results of USAF Survey Number 73-89. Report (AD-775-047). Lowry Air Force Base CO: Technical Training Division, Air Force Human Resources Laboratory, January 1974.

Mockovak, William P. An Investigation and Demonstration of Methodologies For Determining the Reading Skills and Requirements of Air Force Career Ladders. Report (AD 777331). Lowry Air Force Base CO: Technical Training Division, Air Force Human Resources Laboratory, January 1974.

Mockovak, William P. Literacy Skills and Requirements in Air Force Career Ladders. Report (AD-A008770). Lowry Air Force Base CO: Technical Training Division, Air Force Human Resources Laboratory, December 1974.

- Ojemann, R.H. "The Reading Ability of Parents and Factors Associated with Reading Difficulty of Parent Education Materials", University of Iowa Studies in Child Welfare, 8:11-32, 1934.
- Post, Thomas J. and Harold E. Price. Requirements and Criteria for Improving Reading Comprehension of Technical Manuals, November 1974. Contract N00024-74-C-5426. Naval Sea Systems Command Technical Publications Branch (ADA 070369).
- Sherman, L.A. "The Literacy Sentence-Length in English Prose", Analyties of Literature. Boston: Ginn and Co., 1893.
- Smith E. A. and R. J. Senter. Automated Readability Index. AMRL-TR-66-22. Aerospace Medical Division, Wright Patterson AFB OH, 1967 (AD 667273).
- Smith, Edgar A. and Peter J. Kincaid. "Derivation and Validation of the Automated Readability Index for use with Technical Materials," Human Factors, 1970: 457-464.
- Spencer, Herbert. "The Philosophy of Style", reprinted in Spencer's Essays, Moral, Political and Aesthetic, New York 1868.
- Taylor, W.L. Application of Cloze and Entropy Measures to the Study of Contextual Constraints in Samples of Continuous Prose. PhD thesis, University of Illinois (1954), Dissertation Abstracts 15 (1955):464-465.
- Taylor, W.L. "Cloze Readability Scores as Indices of Individual Differences in Comprehension and Aptitude", Journal of Applied Psychology. 41:19-26 (1957).
- Vaughan, David K. and Capt Thomas R. Ferkinhoff. Readability Formulas and Technical Order Preparation in the United States Air Force. Report to the Society for Technical Communications. August 1989.
- Washburne, C. and Morphett, M.V. "Grade Placement of Childrens' Books," Elementary School Journal, 38:353-364 (January 1938).

### Vita

Captain Thomas R. Ferkinhoff was born on 9 November, 1954 in Glendale, California. He graduated from Notre Dame High School in Sherman Oaks, California in 1972 and attended California State University Northridge, where he received the degree of Bachelor of Arts in Biology in 1977. Captain Ferkinhoff entered the Air Force in 1979 through OTS. Upon graduation he received a commission and was assigned to navigator training. He completed navigator training and received his wings in 1980. He then served as a KC-135 navigator and instructor navigator at both Loring AFB, Maine and Fairchild AFB, Washington. While stationed at Fairchild AFB, Captain Ferkinhoff completed a Masters of Science degree in Counseling and Guidance from Eastern Washington University in May of 1988. In 1986 Captain Ferkinhoff was selected to serve as the KC-135 Emergency War Order Training Officer and remained there until he entered the School of Systems and Logistics, Air Force Institute of Technology, in 1988.

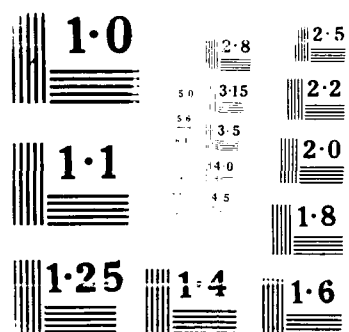
Permanent Address: 623 Priscilla Lane  
Burbank, California 91505

REVIEW OF THEIR DEVELO. (U) AIR FORCE INST OF TECH  
WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.

UNCLASSIFIED T R FERKINHOFF SEP 89 AFIT/GLN/LSR/895-22 F/O 5/2

NL





UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT  Approved for public release; distribution unlimited		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S)  AFIT/GLM/LSR/89S-22			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION School of Systems and Logistics		6b. OFFICE SYMBOL (If applicable) AFIT/LSM	7a. NAME OF MONITORING ORGANIZATION		
6c. ADDRESS (City, State, and ZIP Code) Air Force Institute of Technology Wright-Patterson AFB OH 45433-6583			7b. ADDRESS (City, State, and ZIP Code)		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code)			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
					WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification)  see box 19					
12. PERSONAL AUTHOR(S) Thomas R. Ferkinhoff, B.A., M.S., Captain, USAF					
13a. TYPE OF REPORT MS Thesis		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year, Month, Day) 1989 September	
15. PAGE COUNT 97					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	Readability, Reading Grade Level, Technical Writing		
05	02				
19. ABSTRACT (Continue on reverse if necessary and identify by block number)					
<p>Title: READABILITY FORMULAS AND AIR FORCE PUBLICATIONS: A REVIEW OF THEIR DEVELOPMENT AND AN EXAMINATION OF THEIR APPLICATION</p> <p>Thesis Advisor: David K. Vaughan Assistant Professor of Technical Communication</p> <p>Approved for public release: IAW AFR 190-1. <i>Larry W. Emmelhainz</i> LARRY W. EMMELHAINZ, Lt Col, USAF 14 Oct 89 Director of Research and Consultation Air Force Institute of Technology (AU) Wright-Patterson AFB OH 45433-6583</p>					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED		
22a. NAME OF RESPONSIBLE INDIVIDUAL David K. Vaughan, Ph.D			22b. TELEPHONE (Include Area Code) (513) 255-6761		22c. OFFICE SYMBOL AFIT/LSR

UNCLASSIFIED

Abstract

This thesis provides a foundation for future research on the subject of readability formulas and their use with Air Force publications. It examines readability's historical roots and studies pertaining to the topic of readability and its application to the United States Military in general, and the United States Air Force in particular.

This presentation also describes and analyzes Air Force policies relative to the readability of its publications. The results of this analysis indicate that the current procedures, employed by the Air Force, inadequately address the readability of publications. The specific problems that were identified fell under three areas.

The first area addresses the Air Force's decision to write Technical Orders to a ninth grade reading level. This decision is unsubstantiated on either economic or efficiency grounds.

The second problem concerns the questionable methodology used by the Air Force to verify that the desired reading grade level has indeed been achieved. The problem revolves around the use and misuse of the Kincaid readability formula.

The final area for concern is the Air Force's decision to recommend using Association Europeene Des Constructeurs De Materiel Aerospatial (AECMA Simplified English Guide for the Preparation of Aircraft Maintenance Documentation in the Aerospace Maintenance Language) as an aid for producing simplified technical writing. This is a problem because AECMA has never been empirically tested.

UNCLASSIFIED

END

FILMED

1-90

DTIC